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# IMPACT OF AN ANTHOCYANIN - RICH BEVERAGE ON THE EFFECTIVENESS OF IN-OFFICE TOOTH BLEACHING: A RANDOMIZED CONTROLLED CLINICAL TRIAL[1]

# IMPACTO DE UMA BEBIDA RICA EM ANTOCIANINAS NA EFETIVIDADE DO CLAREAMENTO DENTAL DE CONSULTÓRIO: UM ENSAIO CLÍNICO CONTROLADO RANDOMIZADO

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**ABSTRACT**

**Objective:** to compare the bleaching effectiveness and the intensity of tooth sensitivity (TS) during in-office dental bleaching between patients consuming anthocyanin-rich beverage (Brazilian açaí) during treatment. **Materials and methods:** Sixty participants were randomly assigned to two groups based on anthocyanin-rich beverage consumption: the experimental group (EG), which consumed 100 mL of açai after dental bleaching, and the control group (CG), with no açai consumption (n = 30). The color change was measured at baseline, after each of the three in-office dental bleaching sessions (35% Hydrogen peroxide) and 7 days after the bleaching protocol using a Vita Classical shade guide and VITA Easyshade spectrophotometer ($\Delta E_{00}$). A Visual Analogue Scale (VAS) (0–10) and a Numeric Rating Scale (NRS) (0–4) were used to record tooth sensitivity (TS) after each session. Statistical tests were performed with an alpha of 5%. **Results:** The consumption of anthocyanin-rich beverage did not interfere with the $\Delta E_{00}$ values, which were similar between the groups at the same evaluation times ($p>0.05$). Also, the consumption of anthocyanin-rich beverage during dental bleaching did not increase sensitivity measured by both the VAS and NRS ($p>0,05$). **Conclusions:** In conclusion, anthocyanin-rich beverage consumption did not impact the effectiveness of in-office tooth bleaching or levels of tooth sensitivity.

**Keywords**: Açai. Dentin sensitivity. Euterpe. Hydrogen peroxide. Tooth bleaching.



**RESUMO**

**Objetivo:** Este estudo visa comparar a eficácia do clareamento e a intensidade da sensibilidade dentinária (SD) durante o clareamento dental de consultório entre pacientes que consumiram açaí brasileiro durante o tratamento. **Materiais e métodos:** Sessenta participantes foram aleatoriamente divididos em dois grupos com base no consumo de açaí: o grupo experimental (GE), que consumiu 100 mL de açaí após o clareamento dental, e o grupo controle (GC), sem consumo de açaí (n = 30). A alteração de cor foi medida no início, após cada uma das três sessões de clareamento dental de consultório (Peróxido de Hidrogênio a 35%) e 7 dias após o protocolo, utilizando a escala de cores Vita Classical e o espectrofotômetro VITA Easyshade ($\Delta E_{00}$). Uma Escala Visual Analógica (EVA) (0–10) e uma Escala de Classificação Numérica (ECN) (0–4) foram utilizadas para registrar a sensibilidade dentinária (SD) após cada sessão. Os testes estatísticos foram realizados com um alfa de 5%. **Resultados:** O consumo de açaí não interferiu nos valores de ΔE00, que foram

semelhantes entre os grupos nos mesmos tempos de avaliação (p>0.05). Além disso, o consumo de açaí durante o clareamento dental não aumentou a sensibilidade medida tanto pela EVA quanto pela ECN (p>0.05). **Conclusões:** O consumo de açaí não impactou a eficácia do clareamento dental de consultório nem os níveis de sensibilidade dentinária.

**Palavras-chave:** Açaí. Clareamento Dental. Euterpe. Peróxido de Hidrogênio. Sensibilidade da Dentina.



## INTRODUCTION

Aesthetic procedures are among the most frequently requested treatments in dental practice. Patients' demand for an attractive smile, particularly regarding tooth color, has markedly increased [1,2]. As a minimally invasive option, tooth bleaching has become one of the most popular approaches to manage discoloration [3]. Techniques include at-home bleaching, in-office bleaching, or a combination of both, most commonly employing hydrogen peroxide or carbamide peroxide gels; 35% hydrogen peroxide is a standard choice for in-office treatments [4].

Tooth discoloration may result from intrinsic or extrinsic factors. Intrinsic staining is related to structural changes within the tooth, such as fluorosis, pulpal hemorrhage, aging, or certain medications [5]. Extrinsic staining, in contrast, arises from chromogenic substances deposited on the enamel surface or acquired pellicle, originating from food, tobacco, inadequate hygiene, or prolonged use of products containing chlorhexidine [5].

The potential impact of dietary chromogens on bleaching outcomes has been widely studied. While beverages such as red wine, black tea, and coffee are traditionally linked to extrinsic staining, clinical trials demonstrate that their consumption during bleaching does not significantly compromise whitening efficacy [6,7,8,9,10]. Nevertheless, some practitioners still advocate the so-called "white diet," recommending the temporary avoidance of pigmented foods to ensure predictable results.

Açaí (*Euterpe oleracea*), a native fruit of the Brazilian Amazon, deserves special consideration. It is exceptionally rich in anthocyanins—flavonoid pigments responsible for its intense purple coloration—and also exhibits potent antioxidant activity [11,12]. This unusual combination of strong pigmentation and high redox potential raises the hypothesis that açaí might interact with bleaching differently

from other flavonoid-rich foods. In addition, its widespread and frequent consumption in Brazil makes it a clinically relevant subject for investigation.

Therefore, the aim of this randomized clinical trial was to evaluate the influence of açaí consumption on tooth color and sensitivity during in-office dental bleaching. The study hypotheses were that açaí intake would not interfere with (2) tooth color change or (3) tooth sensitivity when compared with the control group.

## MATERIALS AND METHODS

### Study Design



This study was approved by the Ethics Committee of the of the Federal University of Ceará, Brazil (protocol n° 1.795.299). The report adheres to the Consolidated Standards of Reporting Trials [13]. The study was an evaluator-blinded, randomized controlled trial (n=30) with a parallel design and an equal allocation ratio, aimed at assessing equivalence. Patients signed the Informed Consent Form and received written instructions for the study duration. Following each of the three in-office bleaching sessions with 35% hydrogen peroxide, the color change was measured at baseline, immediately after each session and 7 days after the bleaching protocol using a Vita Classical shade guide and VITA Easyshade spectrophotometer (ΔEab). Also, all patients completed the Visual Analog Scale (VAS) and Analog Numerical Scale (ANS) to assess weekly sensitivity.

### Settings and Place Where Data Was Collected

The study was conducted at the Dental Clinic of the Federal University of Ceará in Sobral, Brazil, with data collected at its dental clinics between September 2018 and February 2019.

### Recruitment

Participants were recruited through digital platforms and institutional clinical settings. Informational materials were disseminated via Instagram®, directing interested individuals to an online form in which personal identification and contact details were provided. Individuals who completed the form were registered in a preliminary database and subsequently contacted by the research team for scheduling an initial evaluation and confirmation of eligibility criteria. Additionally, patients receiving routine dental care at the university clinics were assessed for potential inclusion in the study.

### Eligibility Criteria

Participants were eligible for inclusion if they were 18 years of age or older and exhibited adequate systemic and oral health. Eligible individuals were required to present maxillary anterior teeth without carious lesions, periodontal disease, or restorations, and with an initial shade of A3 or darker. Exclusion criteria included the presence of gingival recession; prosthetic restorations or previous endodontic treatment affecting anterior teeth; existing dentin hypersensitivity or prior desensitizing treatment; severe intrinsic discoloration related to tetracycline use; current use of analgesic, anti-inflammatory, or opioid medications; smoking; fixed orthodontic appliances; parafunctional habits such as bruxism or clenching; clinically detectable tooth cracks; previous history of tooth bleaching; pregnancy or lactation; and known hypersensitivity to any materials employed in the study.



### Sample size calculation

In this clinical trial, the primary outcome used for sample size estimation was the objective color change, measured as ΔEab. The sample size calculation was based on the study by [14], which indicated that 52 participants would be required to achieve an 80% probability of detecting a decrease in the secondary outcome (the mean absolute risk of sensitivity in the control group) from 63% to 36% in the experimental group ($\alpha = 0.05$). Assuming an increase in the primary outcome measure from “4” in the control group to “5” in the experimental group, at least 16 patients would be necessary in each group. To account for a potential dropout, 60 participants were initially included in the study. This calculation was performed using web-software freely available online (www.sealedenvelope.com).

### Generation of the random sequence and allocation concealment

Randomization was performed using a block design with a 1:1 allocation ratio through an online randomization platform. A total of 60 participants were allocated into two groups of equal size according to açaí consumption: an experimental group and a control group, each comprising 30 individuals. During the initial appointment, participants were questioned regarding their habitual intake of açaí. Individuals who reported no consumption were assigned to the control group, whereas those who reported consumption were allocated to the experimental group. For both groups, the in-office tooth bleaching protocol was identical and consisted of the application of a

35 percent hydrogen peroxide bleaching agent (Whiteness HP Maxx AutoMixx, FGM, Joinville, SC, Brazil).

Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes containing the group assignment. The investigator responsible for generating the random sequence and maintaining blinding did not participate in the clinical intervention. Immediately before the bleaching procedure, the operator opened the corresponding envelope to identify the participant's assigned group.

**Study Intervention**



The bleaching procedure was performed by a dentist with more than 10 years of clinical experience. The procedure began with Robinson brush prophylaxis and prophylactic paste (Shine, Maquira, Maringá, PR, Brazil) applied to all teeth for baseline color evaluation. After the color evaluation, the bleaching session commenced with relative isolation using a lip retractor (Arc Flex, FGM, Joinville, SC, Brazil), gauze, and a light-curing gingival barrier (Top Dam, FGM, Joinville, SC, Brazil). The barrier was light-cured for 30 seconds every two teeth (LED unit DB-685, 1100 mW/cm$^2$, Dabi Atlante, Ribeirão Preto, Brazil). The application followed the manufacturer's recommendations (Table 1): three single-application sessions of Whiteness HP Maxx AutoMixx *35%* for 45 minutes per session, with a 7-day break between them. Both maxillary and mandibular arches were treated, extending from the second premolar on one side to the second premolar on the opposite side. At the end of each session, the bleaching gel was removed using an endodontic suction cannula followed by rinsing with distilled water.

**Table 1:** Composition and application protocol for in-office dental bleaching.

| **Product** | **Composition** | **Application Regimen** |
|---|---|---|
| Whiteness HP Automixx 35 % Plus (FGM, Joinville, SC, Brazil) | Hydrogen peroxide 35%, thickener, colorant, glycol, Inorganic fillers and water. | 1. Dental prophylaxis performed.<br>2. Initial shade recorded using a shade guide.<br>3. Lip retractor inserted. Gingival barrier applied (0.5 mm over cervical area) and light-cured for 20s.<br>4. Mixing tip attached to the Whiteness HP Automixx 35% syringe.<br>5. Uniform 1 mm gel layer applied to buccal surfaces.<br>6. Gel remained on teeth for up to 45 min.<br>7. Gel position checked periodically.<br>8. Aspire excess gel, wash your teeth and remove the gingival barrier. |

**Source:** Authors.

### Diet of the participants

Participants were questioned regarding their habitual weekly intake of açaí. Individuals who reported no açaí consumption were assigned to the control group and instructed to refrain from ingesting dietary chromogens and other pigmented substances throughout the bleaching period, including black tea, coffee, tomato-based sauces, cola beverages, red wine, grapes, ketchup, mustard, beets, carrots, chocolate, soy sauce, artificially colored chewing gum, berries, açaí, and chlorhexidine-containing products.

The EG patients were provided with a form to record their weekly açaí consumption, in addition to the amount provided by the study. All records were collected at the beginning of the next session.



### Color Evaluation

The color was recorded before, after the first, second, and third bleaching sessions, and 7 days after the completion of the treatment. The anterior teeth staining was measured by two independently calibrated researchers (Kappa = 0.85). In the event of a disagreement during the evaluation process, the evaluators were required to reach a consensus before the participant could be excused. The recordings were conducted in a controlled environment with consistent lighting conditions, and the teeth were kept hydrated.

### Subjective Method

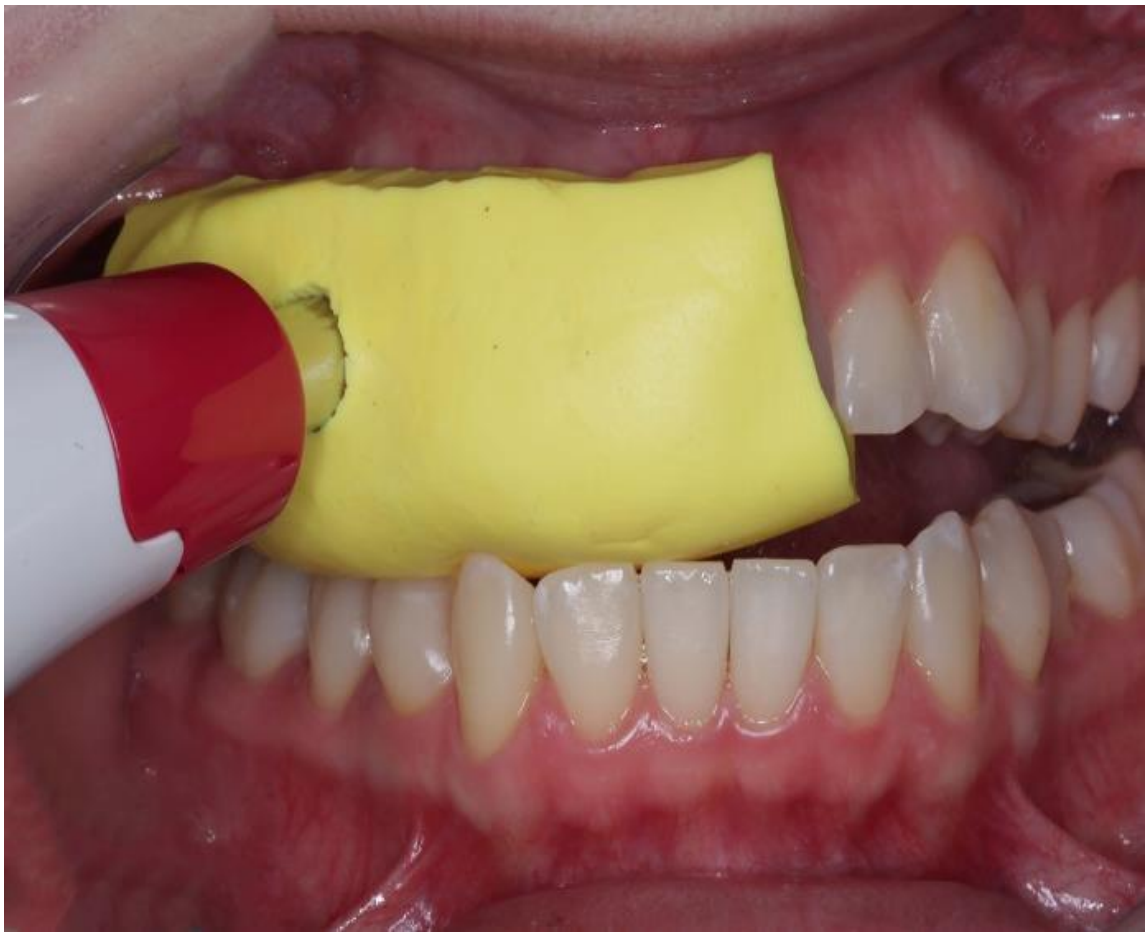
Subjective color assessment was carried out using the Vita Classical shade guide (Vita Zahnfabrik, Bad Säckingen, Germany). The shade tabs were organized according to value, ranging from the highest value score [1] to the lowest [15], in the following sequence: B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, and C4. Shade evaluation was restricted to the middle third of the maxillary right canine.

### Objective Method

Objective color measurements were obtained using a Vita Easyshade Advance 4.0 spectrophotometer (Vita Zahnfabrik, Bad Säckingen, Germany). To ensure measurement reproducibility, an impression of the maxillary arch was taken with condensation silicone (Perfil, Rio de Janeiro, RJ, Brazil), from which a custom positioning index for the anterior teeth was fabricated. This index was fitted to the buccal surface of the middle third of the maxillary right canine and perforated to

permit accurate placement of the spectrophotometer probe. The perforation was created using a circular biopsy punch with a 6-mm diameter (Biopsy Punch, Miltex, York, NJ, USA) (Figure 1).

**Figure 1:** Color evaluation using the VITA Easyshade.



**Source:** Authors.



Color evaluation was performed with a spectrophotometer by recording the L*, a*, and b* parameters based on the CIEDE2000 color space, as defined by the Commission Internationale de l'Éclairage (CIE). This system is widely accepted for expressing color differences in a manner that closely reflects human visual perception and clinical significance. In this model, the L* parameter corresponds to lightness, while chromatic components are described by a* and b*, with a* indicating shifts along the red–green axis and b* representing variations along the blue–yellow axis. Variations in these parameters, expressed as ΔL*, Δa*, and Δb*, denote the difference between baseline and subsequent measurements and were calculated using the CIEDE2000 formula, as shown below.

$$\Delta E_{00} = \left[ \left( \frac{\Delta L'}{K_L S_L} \right)^2 + \left( \frac{\Delta C'}{K_C S_C} \right)^2 + \left( \frac{\Delta H'}{K_H S_H} \right)^2 + R_T \left( \frac{\Delta C'}{K_C S_C} \right) \left( \frac{\Delta H'}{K_H S_H} \right) \right]^{1/2}$$

Tooth color prior to bleaching was quantified by ΔE values at each evaluation time point. The CIEDE2000 results were interpreted according to 50%:50% perceptibility and acceptability criteria, with threshold values established at 0.8 for perceptibility and 1.8 for acceptability, as previously reported.

### Tooth Sensitivity

Tooth sensitivity was self-reported daily throughout the bleaching period using two validated assessment tools. The Numerical Rating Scale (NRS) was applied with scores ranging from 0 to 4, in which 0 indicated absence of sensitivity, 1 mild sensitivity, 2 moderate sensitivity, 3 considerable sensitivity, and 4 severe sensitivity. In addition, the Visual Analog Scale (VAS) was used, consisting of a 10-cm horizontal line scored from 0 to 10, where 0 represented no discomfort and 10 represented the greatest possible discomfort. Participants were instructed to indicate the perceived intensity of tooth sensitivity by placing a vertical mark on the horizontal line, and the recorded value was determined by measuring the distance in millimeters from the origin of the scale [4,6].



## STATISTICAL ANALYSIS

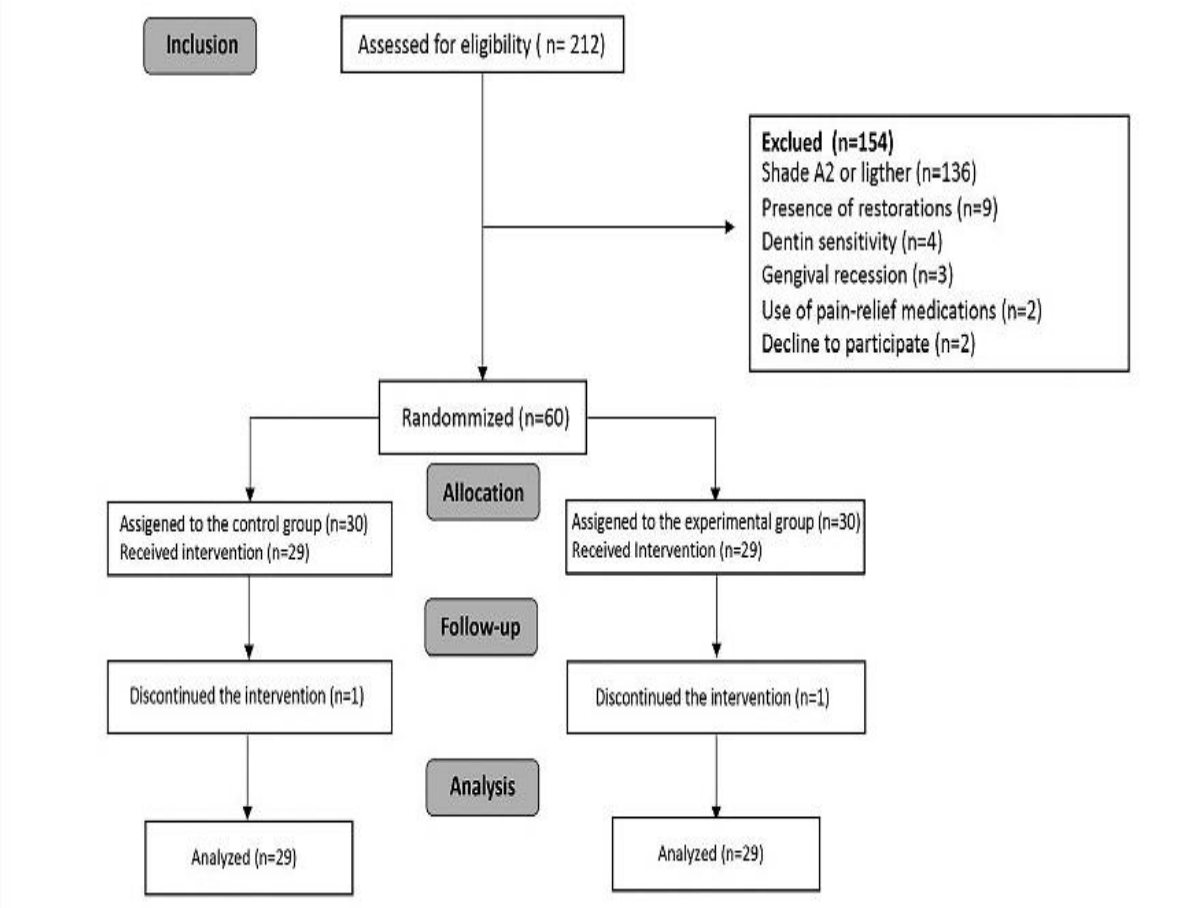
### Results

All statistical analyses were performed by a statistician blinded to group allocation. Data analysis was carried out using SigmaStat software (Systat, Palo Alto, CA, USA). The assumptions of normality and homogeneity of variances were assessed using the Shapiro–Wilk and Levene tests, respectively. Color change data were analyzed by two-way analysis of variance (ANOVA) with repeated measures, considering evaluation time and group (experimental or control) as the main factors. Tooth sensitivity outcomes were analyzed using the Kruskal–Wallis test followed by Dunn's post hoc test. A significance level of 5% was adopted for all analyses.

### Characteristics of the Included Participants

According to the inclusion criteria, 60 of the 212 volunteers evaluated were included in the study. Two participants were lost during the bleaching treatment (Figure 2).

**Figure 2**: CONSORT flowchart of the study design phases.




**Source:** Authors.



### Color evaluation - subjective method

The results of the subjective assessment of color change (VITA Classical shade guide) are presented in Table 2. Regarding the interaction group, there was no statistical difference between the control and the experimental groups at all the evaluation times ($p>0.05$).

Significant bleaching was observed for both study groups compared with baseline values, with the lowest mean values recorded after the third session ($p=0.673$). With regard to assessment time, all bleaching sessions resulted in a statistically significant color change ($p<0,05$), with the exception of the second to third session in the control group, in which there was no significant color change ($p>0,05$).

**Table 2:** Mean (standard deviation) of color assessment measured by VITA Classical shade guide after in-office bleaching sessions.

| | Baseline | 1st session | 2st session | 3st session |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **EG** | 11.4 (0.7) A a | 5.4 (3.0) A b | 3.7 (2.5) A c | 2.5 (1.3) A d |
| **CG** | 11.3 (0.7) A a | 4.8 (2.6) A b | 2.8 (1.4) A c | 2.3 (0.7) A c |

***Abbreviations:** EG: Experimental group; CG: Control group. Different capital letters indicate statistical differences within the column, while different lowercase letters signify differences within the row ($p < 0.05$).
**Source:** Authors.

### Color Evaluation - Objective Method

The results of the objective assessment of color change are presented in Table 3. The consumption of açaí did not interfere with the $\Delta E_{00}$ values, which were similar between the groups at the same evaluation times ($p>0.05$). Likewise with subjective analysis, a statistically significant color change was obtained after the third session for both study groups ($p<0,05$).



**Table 3**: Mean (standard deviation) of color change ($\Delta E_{00}$) measured by VITA Easyshade after in-office bleaching sessions.

| | 1st session | 3st session |
|---|---|---|
| **EG** | 10.2 (2.3) A b | 14.5 (3.3) A a |
| **CG** | 10.7 (2.2) A b | 15.7 (2.3) A a |

***Abbreviations:** EG: Experimental group; CG: Control group. Different capital letters indicate statistical differences within the column ($p < 0.05$), while different lowercase letters signify differences within the row ($p < 0.05$).
**Source:** Authors.

### Tooth Sensitivity

The results of the Visual Analog Scale (VAS) and Numerical Rating Scale (NRS) are presented in Table 4. Regarding the interaction group, there was no statistical difference between the control and the experimental groups at all the evaluation times ($p>0.05$). For the NRS scale, sensitivity increased with each session, while for the VAS scale, it only increased significantly from the first to the third session ($p<0.05$).

**Table 4**: Mean (standard deviation) of tooth sensitivity after in-office bleaching sessions.

| Visual Analog Scale (VAS) | 1st Session | 2st Session | 3st Session |
|---|---|---|---|
| **EG** | 5.4 (4.9) A b | 7.3 (6.3) A ab | 9.7 (8.2) A a |

| | | | |
|---|---|---|---|
| **CG** | 4.8 (4.4) A b | 6.2 (5.3) A ab | 8.0 (5.6) A a |
| **Numerical Rating Scale (NRS)** | **1st session** | **2st session** | **3st session** |
| **EG** | 2.1 (1.2) A c | 2.5 (1.2) A b | 3.0 (1.1) A a |
| **CG** | 2.0 (1.0) A c | 2.3 (1.0) A b | 2.8 (1.1) A a |



*__Abbreviations:__ EG: Experimental group; CG: Control group. Different capital letters indicate statistical differences within the column ($p < 0.05$), while different lowercase letters signify differences within the row ($p < 0.05$).
**Source:** Authors.

## DISCUSSION

The present study demonstrated that the consumption of an anthocyanin-rich beverage (Brazilian açaí) did not influence the effectiveness of in-office tooth bleaching or the levels of tooth sensitivity. This finding aligns with evidence from previous in vitro and clinical studies showing that commonly consumed beverages, such as coffee, tea, cola, and red wine, generally do not compromise the efficacy of tooth bleaching procedures, although red wine may produce a transient staining effect [6, 8]. Together, these results highlight the overall robustness of modern bleaching protocols against typical dietary chromogens and suggest that anthocyanin-rich beverages may not interfere with treatment outcomes.

Anthocyanin-rich beverages represent a distinct group of dietary pigments, as they combine intense coloration with pronounced antioxidant properties. Açaí has been reported to contain anthocyanin concentrations ranging from 10.20 to 14.33 mg/g in non-commercial purple samples [16], values that are considerably higher than those observed in most other fruits. Moreover, its anthocyanin content has been described as being 15 to 30 times greater than that found in red wine [3], a beverage widely recognized for its chromogenic potential. This exceptionally high pigment concentration supports the use of açaí as a suitable clinical model for investigating whether anthocyanidins are capable of influencing the effectiveness of tooth bleaching procedures.

Based on the results of this trial, the hypotheses were accepted: consumption of an anthocyanidin-rich beverage did not interfere with tooth color change or

sensitivity when compared with the control group after in-office bleaching sessions. Although bleaching progressed more rapidly—within two sessions—in the control group, this difference was not clinically significant. Sensitivity increased after each session in both groups, but no statistically significant differences were observed.

These observations are clinically relevant, as the recommendation of a so-called “white diet” is still commonly adopted by clinicians as a requirement for successful tooth bleaching. Such guidance has traditionally been grounded in in vitro assumptions suggesting that dietary pigments could negatively affect bleaching outcomes [16]. In contrast, recent systematic reviews have demonstrated that the intake of pigmented foods does not significantly compromise bleaching effectiveness when compared with adherence to a restrictive diet [10,17]. From a biological standpoint, extrinsic discoloration is primarily associated with the adsorption of macromolecular compounds onto the enamel surface rather than deep penetration into the tooth structure. Enamel functions as a semipermeable barrier, allowing the diffusion of only small molecules [20].



In this study, participants maintained consistent oral hygiene (three daily brushings), and prophylaxis was performed before each bleaching session, which likely minimized the effect of dietary chromogens. In addition, bleaching gels eliminate the acquired pellicle and superficial stains upon application, enabling peroxide radicals to penetrate enamel and oxidize chromophores within dentin [14, 20]. This mechanism explains why anthocyanidin-rich beverage consumption did not impair the bleaching effect after three sessions, supporting the notion that dietary restriction of pigmented foods may not be clinically necessary.

Tooth discoloration is modulated not only by the presence of chromogenic pigments but also by acidic conditions, which may decrease enamel microhardness, increase surface roughness, and contribute to dental sensitivity. Common staining agents exhibit varying acidity levels, with coffee presenting a pH range of 4.5 to 6, cola beverages ranging from 2.5 to 3.5, and açaí pulp between 4.46 and 5.12 [18,20]. This pH profile may help explain the absence of additional sensitivity associated with açaí consumption, in contrast to findings reporting increased sensitivity following the intake of cola-based drinks [8,9]. Rather than being diet-related, the gradual increase in tooth sensitivity observed in both groups is more plausibly attributed to the bleaching agent itself, as hydrogen peroxide enhances enamel permeability and diffuses into the dentin, releasing reactive byproducts into the pulp chamber and eliciting transient inflammatory responses [14].

Therefore, the consumption of an anthocyanidin-rich beverage did not compromise the efficacy of in-office bleaching or increase tooth sensitivity. A limitation of this study was dietary control, as ensuring full adherence to pigment restriction in the control group was challenging. Moreover, color and sensitivity were not evaluated in the immediate days following bleaching sessions, which could provide additional insight into short-term effects.

## CONCLUSION

The consumption of an anthocyanin-rich beverage (açaí pulp) did not affect the effectiveness of in-office bleaching or tooth sensitivity. These results suggest that dietary restrictions related to anthocyanin-rich foods and beverages may not be necessary during bleaching treatments.



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### Conflict of interests

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

### Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Federal University of Ceará. The approval code for this study is: 1.795.299.

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